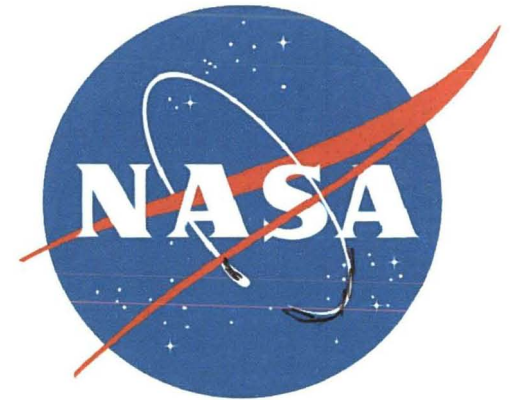




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# Implementation of Systems Engineering Practices into a Capstone Course

ESMD Space Grant Faculty Senior Design Training  
Workshop

*27 – 28 July, 2011 Kennedy Space Center*

**Peter Schmidt**

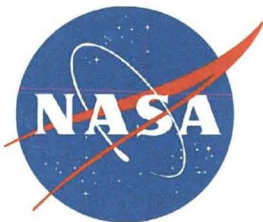
NASA ESMD Faculty Fellow (2010 – 2012)

Assistant Professor, Mechanical Engineering Technology



# Presentation Overview

- NASA Senior Design Opportunities
- NASA Systems Engineering Philosophy
- Implementation Steps
- Implementation Outcomes
- Questions and Answers
- Discussion



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# NASA Exploration Systems Mission Directorate Faculty Fellow Program

- Prepares faculty members to enable their students to complete senior design projects with potential contribution to NASA ESMD objectives.
- Open to all faculty with Capstone Design Responsibilities
- Predefined projects are listed, but not restrictive.
- NASA Centers: Ames Research Center (ARC) , Goddard Space Flight Center (GSFC) , Johnson Space Center (JSC), Kennedy Space Center (KSC) , Langley Research Center (LaRC), Marshall Space Flight Center (MSFC)

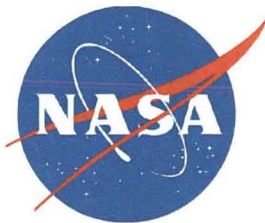


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# NASA Exploration Systems Mission Directorate Senior Design Project List

- Provides students with senior design project ideas with potential contribution to NASA ESMD objectives
- Provides NASA technical representative to act as external customer / technology mentor / requirements source
- Open to all faculty
- Predefined projects are listed
- Funding available through the National Space Grant Organization



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# NASA System Engineering Philosophy

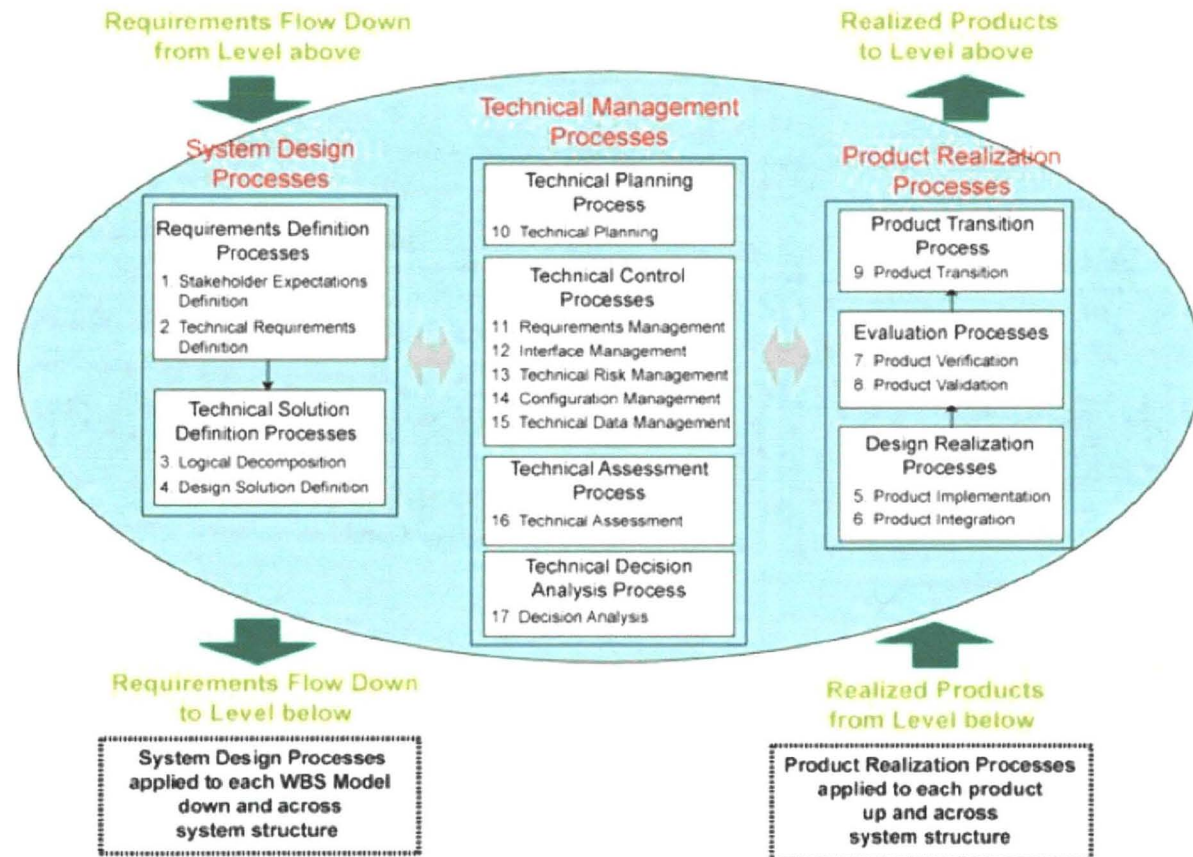
- Project Structure Formalism
- Uses an “engine” approach (Closed Loop) rather than a process approach (Open Loop)



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# NASA System Engineering Engine

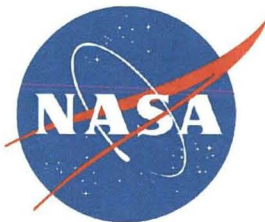


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# NASA System Engineering Importance

- Similar to the formalism used in the built environment (A&E Firms)
- Important for technology workers as the workplace stresses teamwork, cross functionality and delivery of integrated systems rather than simple components.



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# Partial UNCC Capstone Project List

- Carolinas Aviation Museum – US 1549 Display Structure
- GE Aviation – Turbine Blade Mounting Disk Production Optimization
- General Dynamics – Bio-Aerosol Delivery Test System
- NASA – Dust Tolerant Quick Connect System
- NASA – Lunabotics Regolith Excavation Robot
- NASA – ARGOS Control Algorithms
- Siemens – Stator Core Assembly Device
- Westinghouse – Lift Mechanism for Nuclear Power Station
- ASEE / DEED / AbilityOne – Articulated Adjustable Keyboard Station



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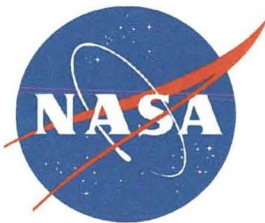


# Lunar Dust Tolerant Connector System

Goal: Design and prototype a dust tolerant connector housing system suitable for use with electrical or fluid COTS connector systems.

Outcome: Students produced a functional prototype, unsuited to further development.

Systems Engineering Impact: NASA SE Handbook used for structure of Requirements Gathering and for guidance on Project Management. A multidisciplinary team was functionally formed.



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# Lunar Regolith Excavation

Goal: Developed a system that will be able to drive to the desired location once on the lunar surface and collect regolith for deposition into a hopper attached to a processing facility.

Outcome: Successful construction of a Lunabotics entry, and delivery of regolith during the competition.

Systems Engineering Impact: NASA SE Handbook used for structure of Requirements Gathering and for guidance on Project Management. A multidisciplinary team was functionally formed.



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# Capstone Implementation Overview

College of Engineering Program.

Departments collaborating: ME/SE/ES, ECE, ET (EE and ME), CE/ENV

Multidisciplinary teams were formed successfully where required.

Systems Engineering Students were included on large capstone teams.



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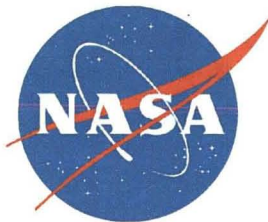


# Implementation Step 1

The SE process encourages communication between disciplines and fosters consideration of the nature of subsystem integration to create a successful end product.

System Engineering is not commonly taught as a part of undergraduate curricula. Most students are unfamiliar with the basic concepts.

A lecture on SE Basics was given to all students



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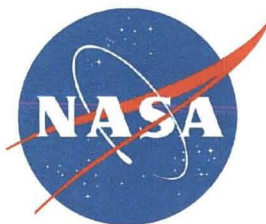
# Systems Engineering Lecture Topics

The SE process encourages communication between disciplines and fosters consideration of the nature of subsystem integration to create a successful end product.

A lecture on Systems Engineering Basics was given to all students:

Difference Between SE and PM  
System Definition  
Systems Thinking  
Multidisciplinary Teams  
Project Life Cycle  
Scope of Work  
CONOPS

Architecting  
TRL  
Systems Hierarchy  
Interface Management  
Margin / Contingency  
Risk Management  
Trade Studies



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# Implementation Step 2

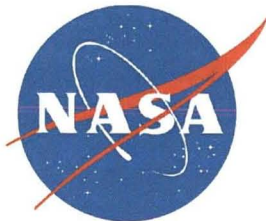
Project management is as an important skill for successful completion of the capstone experience and is highly valued by employers. It is also a different skill than SE.

Most students have little formal project management training.

Project management deliverables are required from each project group.

WBS with Tracking of Actuals

Schedule



Project Budget



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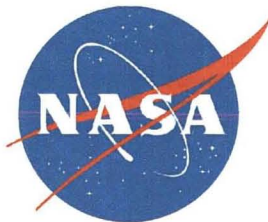


## Implementation Step 3

Ubiquitous use of CAD / CAE software has caused the abilities of students to interpret engineering drawings and illustrations to degrade. Buzzwords such as “CAD as Master” used in the automotive and aerospace industries exacerbate the issue.

Ability to think in three dimensions and to properly use engineering documentation is essential to anyone working in a technical field where physical products are produced or used.

A lecture on documentation and configuration control is given to the entire student cadre.



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# Documentation and Configuration Control

## Lecture Topics

What is documentation?

What is configuration control?

What causes documentation changes?

How are documentation changes managed?

Material Review Boards (MRBs)

How are interfaces between subsystems managed and defined?

Documentation nomenclature and numbering

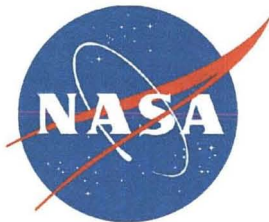
Document custodians

Document release and change systems

Drawing Standards

Document Approval

Documentation Control Software (Enterprise Resource Planning)



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# SE Specific Course Outcome 1

Students have been made aware of documentation and standards required for successful completion of complex projects.

Student deliverables include:

A Design/Fabrication Package with Drawing List

A Bill of Materials / Parts List

Interface Definition and Control Documents

College of Engineering Documentation Standards are in process



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## SE Specific Course Outcome 2

Students have become more aware of codes, standards, specifications and statutes that govern engineering work in practice.

These organization standards are regularly used in project work, and are available to the students in the University Library.

ASTM

ISO

UNS

IEEE

ASME

ASHRAE

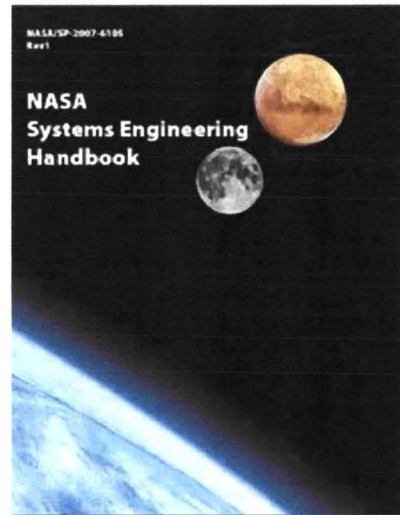


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# SE Specific Course Outcome 3

The NASA SE handbook provides an example to students of the structure necessary in the work place to deliver a successful project.



This document is available as a pdf file on the course MOODLE site.



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# Resources

Systems Engineering Handbook:

<http://education.ksc.nasa.gov/esmdspacegrant/Documents/NASA%20SP-2007-6105%20Rev%201%20Final%2031Dec2007.pdf>

NASA ESMD Website :

<http://education.ksc.nasa.gov/esmdspacegrant/index.htm>

NASA ESMD Senior Design Project List:

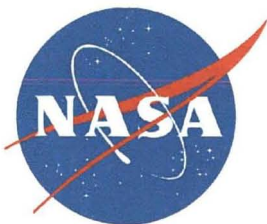
[http://education.ksc.nasa.gov/esmdspacegrant/Sr\\_Design.htm](http://education.ksc.nasa.gov/esmdspacegrant/Sr_Design.htm)

UNCC SD Website:

<http://srdesign.uncc.edu/>

Peter Schmidt:

[pschmid3@uncc.edu](mailto:pschmid3@uncc.edu)



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Thank you for your attention

Questions?

Discussion?

Comments?



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